

# Assessment of impacts of visitors' activities on vegetation in Zhangjiajie National Forest Park

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**Abstracts:** In three scenic spots (Golden Whip Crag, General Rock, and Treasure Box for Celestial Books) of Zhangjiajie National Forest Park, four sample plots were selected to investigate the number of tree skin scars damaged by visitors and the quantity and species of vegetation. The analysis results indicated that trees located along the sides of roads are seriously cut by visitors, especially in Yellowstone Village and Gold Whip Stream areas. The wounded degree was mainly related to tree species, smoothing degree, and the distance from tree to the edge of roads. The impacting degree of tourism activities on vegetation was confirmed by Impact Vegetation Index ( $I_{VI}$ ). On the three most visually impacts sites, the range of  $I_{VI}$  value varied from 59.4% to 87.5%. This showed that the vegetations of the sides of the trails were impacted seriously. To these problems, some suggestions are proposed for the park's management on visitors.

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## Introduction

National parks and other protected areas have become popular destinations of nature-based tourism or ecotourism in the past two decades. According to the World Tourism Organization (WTO), ecotourism generated revenue of \$20 billion a year, and attracted 20% of global international tourists. But ecotourism may have negative impacts on wild resources. Sometimes it can even destruct the resources and environments of scenic spots. Many studies in this aspect have been carried out by foreign researchers (Hin *et al.* 2000; Cole 1990; Cole *et al.* 1992; Dale *et al.* 1974; Elison *et al.* 1996; Feng *et al.* 1999; Gaddy *et al.* 1987; Gold 1986), but few reports were found in China.

Huang Yi (1990) studied the impacts of tourism development on the quality of Zhangjiajie National Forest Park in terms of air pollution, water contamination, and plant pollution. However, little was known in regard to the visitors' trampling on vegetation. In our study, we investigated the main trees along the trail and vegetation in Zhangjiajie National Forest Park, and analyzed the impact of tourist on trees and vegetation.

## Study area

Zhangjiajie National Forest Park, the first national park of China, was established in 1982 (Wang 1988). It then be-

came the main component of Wulinyuan Scenic spots, which was placed into the list of "the World Natural Relics" by the United Nation's Educational, Scientific, and Cultural Organization (UNESCO) in 1992. In the scenic spots there are more than 3 000 plant species, of which, 28 species are under state protection. Ninety-eight percent of the area is still covered by primeval secondary forests. There are 550 tree species in the area, twice as many as that in Europe, and 30 species of wildlife to be protected by the state. In the park there are thousands of famous narrow sandstone pillars and peaks, and many of them are over 200 m high.

Tourism income is the leading source of revenues in Zhangjiajie. From 1982 to 1999, the park received a total of 7.73 million visitors, who brought the park with revenue of RMB 3.6 billion yuan. Tourism income in 1999 amounted to 48.4 million yuan. From May to October in a year, the park attracts 85% of the total visitors of the park, and more than half of the visitors visit the park on weekends.

## Methods

### Measurement of scars

Due to the spatial limitation of recreational activities, the major activity in the park is hiking along the slate-paved trails. Vegetation in the areas along the two sides of trails is the most vulnerable to be damaged. Most of accessible areas are covered by matured trees dominated by Chinese fir. The sampling sites of scared trees are selected in almost all impacted areas, while sampling sites of trampled ground vegetation are limited in the most visually impacted areas.

Past scars increase in size with the growth of the trees and turn black in color with the lapse of time. These scars

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become an important factor that affects visual experience of visitors. To understand the situation of scars, four 10 m × 10 m sample plots in typical areas of each trail were selected. Tree species, number of trees, and damaged trees are recorded. For damaged trees, height, diameter at breast height, roughness of bark, distance from trail, number of cuts, and direction and height of cuts were examined and measured. For determining the extent of scars, roughness of barks, the directions to trail, and age of scars, a three-level standard was set up as follows

We define the degree of scars as *Light* (number of scars is less than or equal to 50), *Moderate* (number of scars is between 51 and 100), and *Severe* (number of scars is more than or equal to 100), roughness of barks as *Smooth*, *Intermediate*, and *Rough*, directions to trail as *Obverse*, *Oblique*, and *Reverse*, and the age of scars as E (more than or equal to 15), M (between 6 and 14), and R (less than or equal to 5).

### Measurement of vegetation

The spots selected are “Gold Whip Crag” in the middle of Gold Whip Stream, “General Rock” and “Treasure Box

for Celestial Books” along the trail of Yellowstone Village. The following factors are examined: dominant species, age (young, middle, and mature), number of species, average height, average diameter at breast height, abundance (measured by numbers for trees, cover percentage for ground cover and shrubs), regeneration of dominant trees. The indexes of cover percentage reduction, floristic dissimilarity (modified model), and vegetation impact are calculated.

## Results and analysis

### Impacts on vegetation

From Table 1, it can be seen that there existed great difference in number of species, average height, average diameter, density, and seedlings between the impacted areas and control areas. For instance, for the spot of “Treasure Box for Celestial Books”, almost all ground cover and shrubs disappeared except one tree species in the impacted area, while there are 35 species in the control area. The similar situation occurred in the spot of “General Rock”.

**Table 1. Impacts by visitor's trampling on vegetation**

Scenic spots	Sample plots kinds	Floristic types	Dominant species	Number of species	Average height /m	Average diameter /cm	Density*	Seedlings**
Golden Whip Crag	Used	Trees	-	1	4.5	8.00	1	0.00
		Shrubs	-	5	3.00	1.50	15.00%	-
		Ground cover	-	8	0.13	-	10.00%	-
	Control	Trees	Chinese fir	1	16.00	15.00	3	3(0)
		Shrubs	-	11	4.00	2.50	75.00%	-
		Ground cover	-	13	0.45	-	98.00%	-
General Rock	Used	Trees	Chinese fir	1	17.00	18.00	2	0.00
		Shrubs	-	-	-	-	0.00%	-
		Ground cover	-	-	-	-	0.00%	-
	Control	Trees	Chinese fir	1	17.00	20.00	4	2(0)
		Shrubs	-	5	1.80	1.50	20.00%	-
		Ground cover	-	12	0.30	-	95.00%	-
Treasure Box for Celestial Books	Used	Trees	Chinese fir	1	10.00	17.00	21	0.00
		Shrubs	-	-	-	-	0.00%	-
		Ground cover	-	-	-	-	0.00%	-
	Control	Trees	Chinese fir	1	12.00	21.00	24	62(5)
		Shrubs	-	13	1.00	2.50	30.00%	-
		Ground cover	-	21	0.60	-	100.00%	-

**Notes:** \*---cover percentage was used to represent density for shrub and ground cover while the number of trees was used to express density of trees. \*\*---the number before bracket stands for number of fir shoots, while the number within brackets stands for seedlings of other species including the fir.

Three indicators such as Cover Reduction ( $C_R$ ), Floristic Dissimilarity ( $F_D$ ), and Index of Vegetation Impact ( $I_V$ ) are commonly used to measure the vegetation variation degree.  $C_R$  is calculated as follows:

$$C_R = [(C_2 - C_1) / C_2] \times 100\% \quad (1)$$

Where  $C_2$  and  $C_1$  are the vegetation cover percentages in control sites and impacted sites, respectively.  $C_R$  is Cover Reduction.

$F_D$  is calculated based on the following formula:

$$F_D = 0.5 \sum |P_{i1} - P_{i2}| \quad (i = 1 - n) \quad (2)$$

Where  $P_{i1}$  and  $P_{i2}$  are the amount of species  $i$  in a control site and in an impacted site, respectively.  $n$  is the number of species.

$I_V$  is calculated based on  $C_R$  and  $F_D$ :

$$I_V = (C_R + F_D) / 2 \quad (3)$$

Where,  $I_{VI}$  is Index of Vegetation Impact.

The calculation of  $F_D$  is simple. First, the herbaceous plants and shrubs are the main factors that influence the percentage of ground cover. However, it is time consuming and never easy to identify and measure the magnitude of a herbaceous species; Second, from the perspective of visitors, an area with diversified species may be more important than an area with a particular species, especially when it comes to herbaceous species. Third, the calculation did not account for the regeneration. To this end, the authors propose a modified calculation as follows:

$$F_D = (\sum N_i / P'_{i1} - P'_{i2}) / P'_{i2} \times 100\% \quad (i = 1 - 4) \quad (4)$$

Where trees, shrubs, herbaceous plants and regeneration species are weighed with proportions being 4, 3, 2, and 1, respectively in this modified calculation.  $P'_{i1}$  and  $P'_{i2}$  are the number of species in a control site and an impacted site. Table 2 shows the results of these three indicators for the three scenic spots.

As indicated in Table 2, the vegetation around "Treasure Box for Celestial Books" was most seriously impacted by trampling, with the  $I_{VI}$  being 87.50 %. The least impacted area is "Gold Whip Crag", while "General Rock" is placed in the middle.

### Damaged trees

A survey of 24 sampling sites in the 6 trails indicated that totally 112 trees from 29 species have been scarred to some extent. Among the 29 species, the species featured with smooth bark, including *Machilus ichangensis*, *Acer fabri*, *Machilus lichyanensis*, *Ilex maerxarpa*, *Cornus controversa*, *Pinus taiwanensis*, *Cinnamomum appelianum*, and *Fagus longipetiolata*, are most seriously damaged. A small number of trees featured by coarse bark were scarred, including the species of *Acer davidii*, *Choerospodias axillaris*, *Castanea fargesii*, *Castanea henryi*, *Cunninghamia lanceolata*, *Cyclocarya paliurus*, *Cryptomeria fortunei*, and *Sorbus alnifolia*.

**Table 4. Analysis of the tree scars damaged by travelers in Zhangjiajie National Forest Park**

Items	Directions to trails			Ratings of scars			Age of scars/a		
	Obverse	Reverse	Oblique	Light	Moderate	Severe	R	M	E
Numbers of trees	19	93	0	26	54	32	10	42	56
Weight (%)	17.0	83.0	0	23.2	48.2	28.6	12.5	37.5	50.0

Notes: E ---the age is more than or equal to 15, M--- the age is between 6 and 14, and R--- the age is less than or equal to 5.

**Table 5. Spatial distribution of damaged trees**

Items	Distance from trail /m			
	≤0.5	0.6-1.0	1.1-1.5	≥1.5
Damaged trees	72	25	13	2
Weight (%)	64.3	22.3	11.6	1.8

Most of surveyed trees are moderately scarred with cuts between 50 nicks and 100 nicks. Relatively, trees with cuts less than 50 or more than 100 nicks account for a small

**Table 2. Evaluation of recreational impacts on vegetation**

Scenic spots	Vegetation indexes		
	$C_R^*$ (%)	$F_D$ (%)	$I_{VI}$ (%)
Gold Whip Crag	89.80	29.05	59.43
General Rock	100.00	50.00	75.00
Treasure Box for Celestial Books	100.00	75.00	87.50

Note: \*---value for ground cover.

Trees along the two sides of Gold Whip Stream were damaged most heavily, with a scarred rate of 40%, followed by those in Yellowstone Village (27.6%), and the trees along the Yuanjiajie was damaged most lightly, with a scarred rate of 7.3% (Table 3). It was found that the trees were most likely to suffer scarring in the areas where are readily accessible. Trees larger than 8 cm in diameter were frequently scarred. The trees at a distance of less than one meter from trails were prone to be scarred.

**Table 3. Investigations of trees damaged by visitors along six trails**

Trails	Sampled trees	Scarred trees	Weight (%)
Yellow Stone Village	98	27	27.6
Gold WhipStream	96	38	39.6
Kidney Stockade	105	16	15.2
Pipa Stream	114	12	10.5
Shadao Ravine	108	10	9.3
Yuanjiajie	123	9	7.3
Total	644	112	17.4

Most of the tree scars face to trails, no scar was found on the backside of the trees, and moderate number of scars were found on the side oblique to trails (Table 4). Most of scars are located at the breast height ranging from 1.2 m to 1.6 m (Table 5).

proportion. About half of the scars occurred 15 years ago, while fewer cuts were in recent 5 years. A possible explanation for this is that the unscarred trees along trails can't be accessed by visitors and the visitor's awareness of resource protection has been increased.

A correlation analysis indicated that the level of cuts was significantly related to the roughness of tree barks and the distance from the trails. The more smooth or closer to the trails the tree was, the more serious the tree was scarred. In view of this point, it is suggested trees with rough bark

should be planted instead of smooth ones along the trails so that cuts can be maximally avoided.

### Conclusions and implications

Since most of the trails wonderfully distribute at the bottom of valleys, visitors are limited geographically to hike along and around the trails. As a result, the impacts of visitors' trampling on vegetation mostly occur in open and flat spaces.

It is essential to manage the vegetation along the two sides of trails from both visitors' and ecological perspectives. The damage of vegetation along trails will lead to the formation of valley, which may finally result in serious run-off of trails. To this end, the monitoring and management of visitors' impact along trails must be strengthened. The following measures should be taken for this purpose:

- (1). The temporary fences should be set up to keep visitors out of those sites that have been seriously impacted, thus the areas can be naturally recovered by plantation.
- (2). More attentions should be paid to the management of stakeholders around scenic spots, particularly "Treasure Box for celestial books" and the "Ethnic Wooden Pavilion" nearby. It is the biggest gathering site along the trail to the top of the mountain. Visitors were likely to be stopped by souvenir hawkers and asked to take pictures or buy their souvenirs. Probably here it is the commercial activities that lead to the crowding of visitors, and consequently the trampling of vegetation.
- (3). Environmental education is an essential component of ecotourism. Conventionally, environmental and ecological educations are conducted in visitor information centers or areas with special interests designated within parks. As the first national forest park in China, Zhangjiajie should take a lead in this regard. However, like many other forest parks, environmental education has not been listed on the agenda of any park management in China.
- (4). One alternative approach to mitigate the impact of visitors on the environment of the over used trails is to channel visitors to less used areas. Historically, the two trails—Yellowstone Village and Gold Whip Stream are the most frequently visited, while the other spots are rarely used. For example, in a survey conducted in July 8, 1997, in peak season, it was found that only 10 users visited Kid-

ney Stockade, accounting for 0.33 per cent of the total 3 039 visits that day. This is the similar case for Shadao Ravine and Yuanjiajie. The reason for less use of these trails is partially due to their less attractiveness and more time and physical consuming than the popular Yellowstone Village and Gold Whip Stream. To increase the use of those less used trails and mitigate the pressures on over-used trails, the park should alter the marketing strategies, improve the accessibility and popularity of those less frequently trails.

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